# ENGINEER, ARCHITECT AND SURVEYOR.

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MEETINGS OF CITY AND TOWN BOARDS.

*The Board of Public Works* of the City of Chicago is in session from 10 to 12 A. M., and from 2 to 4 P. M., every day, at the City Hall, S. E. cor. of Adams and La Salle streets. Parties presenting plats of subdivisions for approval, will leave them with Otto Peltzer, Chief Draughtsman

*The Office of the West Chicago Park Commissioners* is at No. 25 South Halsted street, and plats for approval may be presented any day between 9 A. M. and 4 P. M. Chas. S. Loding, Secretary.

*The Trustees of the Village of Hyde Park* meet at the Town Hall in Hyde Park, on the first and third Mondays of each month, where plats may be presented, or they may be left with Chas. S. Pope, Village Clerk, at Room 16, Kent's Building, 153 Monroe st., before 11.30 A. M. Saturday. Plats approved by the Hyde Park Council are retained for record.

*The Board of Trustees of the Town of Lake* meets at the Town Hall, at the Stock yards every Monday, from 9 A. M. to 4 P. M.

*The Board of Trustees of the Town of Jefferson* meets at Jefferson Village on the first Saturday of each month. Plats may be left with S. M. Davis, 43 Bryan Block.

*The Trustees of the Town of Cicero* meet at the Town Hall in Austin, at 8 A. M., on the second Monday and last Saturday of the month.

Secretaries of the different Boards will do us a favor if they will inform us of any changes that may from time to time be made in the meetings or regulations of their several Boards.

DIRECTORY.

Academy of Sciences---No. 263 Wabash Avenue. Meets second Tuesday of every month, at 7.30 P. M.

Historical Society—209 Michigan Avenue. Dr. Bryeson, Librarian.

Civil Engineers' Club of the Northwest—Meets at the rooms of the Academy of Sciences, the second Monday of each month. E. S. Chesbrough, Pres. L. P. Morehouse, Sec'y.

Free Library—S. E. cor. Wabash avenue and Madison street. Open from 9 A. M. to 9 P. M.

Chicago Chapter of the American Institute of Architects—145 Clark st., Rooms 52 and 53. Meetings, first and third Thursday of each month. President, W. W. Boyington; Vice President, P. B. Wight; Secretary, C. C. Miller; Treasurer, Jas. R. Willett.

## *CONSTRUCTION OF DAMS.*

In view of the recent disaster at Mill River, Mass., we reproduce here the views of the Hon. Wm. J. McAlpine, one of the heads of the Civil-Engineering profession in this country, on the subject of earthen dams. In a recent letter to the *Albany Argus*, he mentions that

The subject was earnestly discussed a few years ago in the public and scientific journals of Great Britain, and at the Institution of Civil Engineers of London. The London engineers were unanimously in favor of dams of masonry, and they expressed a strong opinion against earthen dams across streams subject to sudden floods. During the discussion Mr. McAlpine was called upon to give the American experience, and he stated that the general practice was to build such dams of earth, claiming that they could be made more secure with that material than with any other. Mr. McAlpine's views were published by the London engineers, and as they contain some of the reasons advanced in favor of earthern dams, may prove interesting at this time. They are substantially as follows:

"There is no difficulty in making a tight dam, either with earth or masonry, nor in making it strong enough to resist any pressure or force which the water may bring against it. The artificial work must be carried down into the natural soil until it reaches a stratum which is entirely impervious to water under the greatest force to which it will be subjected. Nine-tenths of the failures of reservoir dams, whether of earth or of masonry, occur at or along the joinings of the artificial and natural materials at the bottom or at the sides of the dam. If an artificial dam rests upon a water-tight rock which also extends upwards to the top at the ends, the necessary water-tight joining may be made with a dam of masonry if great care is used; but if the foundations or sides are of earth, or partly of earth and rock, the difficulty of connecting the masonry and the earth so as to secure a water-tight joining is very great, and with uneducated or inexperienced contractors almost always fails. An earth dam may be connected with either a rock or an earthen foundation with perfect certainty if proper precaution is taken. Water abhors an angle, and a system of "toothing" may be adopted by which the water seeking to escape between the artificial and natural jolnings is compelled to follow so many right angles that its whole force—whatever its head may be—will be destroyed, and no damaging leak can occur. Dams of earth also require a self-acting spill-way of sufficient length and depth below the top of the dam to discharge the greatest possible floods. It is never safe to depend upon gates to discharge such floods, as they often occur in the night, or when there is no person to promptly attend to them. The earthen dam should be carried from three to four feet above the level of the water in the pool above, at its greatest possible elevation during a period of the greatest floods. All earthen dams made in this manner will be more tight and secure than one of masonry."

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MAIN SEWERS should have an inclination of 1 in 240, or, the minimum velocity of the water flowiug therein must not be less than 2.5 ft. per sec. upon the frictional surface. House drains communicating with more than one water-closet should not be less than 6″ diameter, nor have a less fall than 1 in 80.

## *IRRIGATION.*

(III.)

In various parts of the world windmills are used for Irrigation purposes; to pump up water from wells. In many places along the lines of our western railroads the water supply is solely obtained by this machine for all requirements. Our limited space this month is therefore devoted to some observations on this very useful machine.

Windmills are of three kinds, the "Post Mill," the "Tower or Smock mill," and the horizontal mill; of which the two former are most generally used, there being several practical disadvantages in the use of the latter, though theoretically more perfect than a vertical mill; its chief defects are the resistance of the vanes which form the sail in returning against the wind, and their friction against the stops which are placed to guide them into the proper positions during their rotation. Post windmills are those in which the whole machine, including its casing, is supported on a pivot firmly fixed and framed into horizontal sills in the ground. Access is gained to their interior by a ladder hinged at one end to the mill, at the other supported by a rope fastened at its other end to the top of the mill, and of sufficient length to allow the ladder to reach within two or three inches of the ground. When the wind changes direction, the mill is turned on its axis by means of this ladder, which thus acts as a lever.

In the Tower or Smock windmill an upright tower supports a moveable cap which supports the wind shaft, and though sometimes turned by hand to face the wind on its changing direction, it is more generally turned by a self-acting mechanism. This automatic arrangement consists of a fan wheel whose blades or vanes are set obliquely to its axis, which is supported on a platform fixed to the cap, exactly opposite to the wind shaft carrying the arms and sails, and jutting out far enough to feel the influence of the wind on the slightest change in its direction. On the axis of this fan wheel is fixed a small bevel pinion which gears into another bevel wheel on one end of a long shaft, to the other end of which is fixed another bevel wheel which gears into a crown bevel on the upper end of a short upright shaft. On the lower end of this upright shaft is fixed a spur pinion, which gearing into a circular rack fixed round the circumference of the top of the fixed tower, moves the cap round when the fan is turned by the wind.

It cannot be said that the forms of windmills most generally used on the western prairies are the most efficient; but as the subject of windmills will be treated more at length in a future article, separate from this series on irrigation, and rules will be given for their construction, it is unnecessary to criticise them further in this place.

The surface of the sails on the "whips" or arms of a vertical mill, were found by Smeaton to give the best effect when concave in form and constructed to a curve of which he gives the necessary data for its construction. When constructed according to his rules, and with the tips of the sails running 2.6 times the velocity of the wind, the mill has an effective power of .29 of the energy of the cylinder of wind which drives it; the diameter of the cylinder being that of the circle passed over by the tips of the whips or arms. In the best designed mills an automatic arrangement reefs the sails when the wind gets too high; there is also a brake attached to the wind shaft for restraining the velocity or stopping the mill entirely.

Dutch wind-mills used for drainage purposes are generally employed in the proportion of one mill with sweeps of from 80 to 90 feet diameter, to every 1,250 acres drained; the lift being 5 feet or under, and working on an average 60 days per annum, raise a total, 1 ft. high, of 695,220,000 cubic feet of water: a poor efficiency, owing to their ancient and defective construction.

The table subjoined, partly compiled from Smeaton and Coulomb, will suffice in most cases that may occur in practice, for determining the efficiency of a windmill as compared with other proposed methods of raising water for irrigation purposes. As Rankine truly says, we are indebted for the art of designing windmills, on general principles, to Smeaton, who communicated the results of an experimental investigation to the Royal Society, England, in 1759; which paper was republished in Tredgold's *Tracts on Hydraulics*.

TABLE NO. 2.

| A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| Feet. | Feet. | Feet. | Cub. Feet | Horse Power. | Horses. | Men. | Gallons. |
| 21.24 | 17.89 | 15.65 | 37.5 | 0.4 | .62 | 5 | 1300 |
| 30.04 | 25.30 | 22.13 | 63.5 | 0.8 | 1.23 | 10 | 2600 |
| 36.80 | 30.98 | 27.11 | 86.0 | 1.2 | 1.85 | 15 | 3900 |
| 42.48 | 35.78 | 31.30 | 107.5 | 1.6 | 2.47 | 20 | 5200 |
| 47.50 | 40.00 | 35.00 | 128.5 | 2.0 | 3.10 | 25 | 6500 |
| 52.03 | 43.83 | 38.34 | 158.0 | 2.4 | 3.71 | 30 | 7800 |
| 56.90 | 47.33 | 41.41 | 190.5 | 2.8 | 4.33 | 35 | 9000 |
| 60.09 | 50.60 | 44.27 | 219.7 | 3.2 | 4.95 | 40 | 10400 |
| 63.73 | 53.66 | 46.96 | 235.1 | 3.6 | 5.57 | 45 | 11700 |
| 67.17 | 56.57 | 49.50 | 257.7 | 4.0 | 6.20 | 50 | 13000 |

A shows the radius of Dutch sails in their common position.
B shows the radius of Dutch sails in their best position.
C shows the radius of Smeaton's enlarged sails.
D shows the quantity of water delivered per minute on an overshot water wheel, 10 feet diameter.
E shows the nominal horse power of a non-condensing steam engine.
F shows the number of horses required of average strength.
G shows the number of men required of average strength.
H shows the quantity of water raised per minute by each of the above mentioned machines.

The utility of columns A, B, C, will be shown more plainly in a future article on the subject of windmills alone. Column F, though dealing in decimals, will be found useful for the purpose of comparison with the other motive powers mentioned; column G, in whole numbers, being the basis. The same remarks apply to column E; the others need no further notice. A careful comparison of the table above, with that on page 19 of our last number will give the reader all the data requisite from which to choose the motive power best adapted to his locality, circumstances and wants, if he intends to irrigate from wells.

[*To be continued.*]

## *THE ALLUVIONS OF THE SOUTH TO BE RECLAIMED BY LEVEES.*

In a previous paper the statement was made that the only practicable method of protecting the Alluvions of the lower Mississippi, is by thorough leveeing.

It is proposed in the present paper to show briefly the reasons for this statement.

The basin of the Mississippi river extends from the source of the Missouri in the northwest, to the Gulf of Mexico in the south,—a distance of more than 4000 miles—and from the Rocky Mountains on the west, to the Alleghanies on the east. Its tributaries are mighty rivers, immense in volume and force. Its navigable waters thread a vast inland country in every direction. Its eastern tributaries and small catchment basins supply a large manufacturing power, and with the numerous and populous districts bordering its many streams as they stretch far away to all the points of the compass, we may consider the Mississippi river the great main artery of our national life and future greatness.

Passing by the geological history of the river bed and lands of the lower Mississippi, we may state at once, that the soil of the alluvions is of the richest and most fertile kind, and capable of producing for the country all it needs of some of the most important productions.

The Climatology and Physical Geography of the country we are considering can be described in no more truthful and forcible language than in that of Colonel C. G. Forshey, found in a paper read by him before the Scientific Congress.

"The Delta extends across eight and a half degrees of latitude. It reaches from the semi tropical lands of the orange and lemon to the border of the ice-floes that, in rigorous winters, block the channel and arrest navigation of the river. Its breadth has an average of about sixty miles. It is thridded and thwarded with interlocking bayous and navigable channels, placing every cultivable acre of its lands immediately upon or very near to steamboat navigation. In this particular it has no parallel known to civilized man.

"The fertility of its soils is of the highest quality; in fact it is almost inexhaustible. Accordingly it produces in its southern two degrees the great staples of rice and sugar in perfection unknown in any other portion of North America. In fact sugar is cultivated only in the delta and south of latitude 31° 30′.

"In nearly all portions of the delta but more thoroughly in the five degrees north from 31°, north of Red River, cotton grows in the delta lands in double the quantities of the best uplands, and corn and sweet and Irish potatoes, in every portion of the delta, grow with facility and abundance and with a minimum of cultivation. The fruits of the tropical and temperate zones are duly distributed and easily grown, each in its proper habitat, over the delta.

"The remarks as to productiveness are applicable to every acre not submerged, and not merely to chosen spots, as upon the uplands adjacent on either side.

"We may compute then 20,920,320 acres of actually productive land upon this alluvial basin, exclusive of irreclamable marsh.

"The rain-fall on the delta, while it is abundant and well distributed, has no extreme exception and crops are invariably produced.

"In the computation of value over such a realm of fertility, by what measures shall we estimate it? Certainly dollars, or gold in any form, will be inadequate to its measure. As well fix a value on freedom and civilization. To a nation or government like the United States, an area of this magnitude lying for six hundred miles across and along the borders of seven States, has no possible valuation estimable in money.

"But the entire delta lies beneath the level of the Mississippi flood waters, as inferable from fact, so apparent in its geology and actual measurements across the basin. The great high waters are so numerous and the ordinary high water so completely above the body of the cultivable lands in the delta, that it were futile to attempt a general cultivation or habitation of the alluvion, without some effectual barriers against the floods."

The various plans proposed or attempted, to reclaim the delta from overflow will now be discussed.

*First*, by Cut offs.

The course of the river is generally very tortuous; its meanderings are like the movements of a serpent; through the narrow neck of its great bends the river often breaks, sometimes shortening its course from twenty miles to less than half a mile. The break through the bend is called a cut-off, and by this means the velocity is suddenly increased for the vast volume of water which previously flowed with an even slope around the bend of perhaps 4 inches in a mile, now leaps through the break with a fall of six feet in a half mile.

The great velocity at once attained lowers the flood level for many miles above the cut off and by its momentum raises the level for a long distance below, so that while the effect of a cut off is beneficial above, it is equally injurious below. To carry out this plan for the general good of the people and the delta, it would require a straightening of the river its whole length and, while such a work would be an impossibility, it would be a task equally as hard to preserve the straightened channel, for the natural regimen of the river through alluvion is a serpentine course, and when diverted from such a course, it instantly commences to tear away its new bonds striving to regain its normal regimen.

It is estimated that the cut offs which have taken place in the last century and a half, have altogether shortened the course of the river five hundred miles—half its entire length—yet the river is as long to-day as in 1725.

We may therefore conclude that the plan of cut offs is impracticable.

*Secondly.* By diverting certain tributaries into other channels, thus relieving the river at its flood of its superabundant water.

It is proposed to turn the upper Missouri into the Red River of the north.

To do this it would be necessary to excavate a channel forty miles long and six hundred feet deep, through a material composed of clayey loam and boulders. The expense would be billions of dollars, and the beneficial result would be small, as the reservoir influence of the river often holds back the floods of the upper

Missouri, so that their influence is not felt in the delta.

It is proposed to divert the Arkansas river by turning it into a chain of lakes and bayous lying between it and Red river.

The water thus diverted from the river at the mouth of the Arkansas, would again appear at the mouth of Red river and thence the volume in the main channel would be as large as before.

The effect then would be only local and the new channel would require to leveed on both sides to save the country through which it passed, from inundation.

The same proposition is made in regard to Red river but the objects to be gained are less than those connected with the Arkansas and the difficulties are much greater—the whole alluvial tract from the mouth of Red river to the Gulf would be inundated on account of the inadequate channels for conveying the water.

Granted, that both the Arkansas and Red rivers could thus be diverted, the result would well be but local and periodical, for it very often happens that the greatest floods are due entirely to a conjunction of floods from the Missouri, upper Mississippi and Ohio.

This plan is, therefore, impracticable.

*Thirdly*, by Reservoirs.

It is proposed by this plan to hold back by artificial reservoirs built in the valleys and catchment basins of the tributaries in the mountains, a sufficient quantity of water to relieve the river during floods and to use it after the flood in the benefit of navigation.

Where are these reservoirs to be located?

Remembering the fact, that the rain-fall which produces the floods, is often beyond the limit of the resevoir sites, it is hard to say where this plan can be carried out. The upper Mississippi and the Missouri and in fact all the tributaries of the lower River, except the southern tributaries of the Ohio, have watersheds of prairies, plain and table lands, where it would be impossible to build suitable reservoirs.

To secure the Delta from the overflow of 1858, it would be necessary to hold back by reservoirs, 600,000,000,000 cubic feet of water, in one month, above the mouth of the Ohio.

Making our calculation from the known amount of rainfall in the vicinity of the reservoir location, it would require an area of 90,000 square miles to have collected the amount; a tract larger than the whole mountain region of the Ohio, But the flood of 1858 was caused more by excessive high waters in the Missouri and upper Mississippi than in the Ohio.

This plan may therefore be considered as impracticable.

*Fourthly.*—By Outlets.

This plan contemplates the opening or leaving open, of what might be called waste weirs on a large scale, to draw off the surplus water from the river in times of flood.

The same objections exist to this plan as to that of diverted tributaries.

On the right bank the plan cannot be carried out above the mouth of Red river.

Below Red river landing there are three natural outlets, but the expense of enlarging them to such an extent, as to enable them to carry the extravasated waters to the Gulf, and the leveeing of those channels themselves, renders the work impracticable.

On the left bank it is proposed to leave open the Yazoo river, where it connects with the main channel, and to levee both sides of it to its debouche at Vicksburg, and thus allow it to carry away from its front enough water to lower the flood level to some extent.

The expense of lowering both sides of the Yazoo river to a sufficient height to hold the waters during floods would build all the levees required along the main channel for many years.

It must also be recollected that the Yazoo river is more of a river than a bayou, that the water entering it from the river at the Yazoo pass, is but a small part of that which is thrown into the main river at its mouth. It has its tributaries on each side in its course through the district; bayous and sloughs, and creeks and rivers of navigable dimensions pour their waters into it on both sides. It cannot be inclosed within levees any more than the mouth of the Yazoo river itself can be closed by a levee along the Mississippi banks.

It has been proposed in other localities below Vicksburg to open outlets, but the same serious objection can be shown to exist in each case, so that we are again forced to the conclusion that this plan also is impracticable.

The only remaining plan is, that of thorough leveeing, or in other words the construction of continuous embankments along the main channel of the river, leaving open the mouths of the main tributaries—like the Yazoo, Arkansas, and Red rivers, which are themselves the main arteries of confluent alluvions of considerable extent.

The Levee system has grown up with the country; commenced by a small dyke at New Orleans, in 1717, it has grown to large proportion.

Not only the banks of the main river have been leveed, but the confluent alluvions have been protected by the same method. There are in the State of Louisiana alone over fifteen hundred miles of levees.

All of the large alluvial tracts of the lower Mississippi are remarkably adapted to reclamation by levee construction, on account of the excellent interior drainage afforded by the main bayous, which are generally parallel in their general direction to the main river. Towards them the ground generally slopes downward from the river and from the highlands; bayous from the direction of the river, and creeks and rivers from the highlands, serve to carry off the surface water and immediate rainfall and the drainage of the uplands. The Yazoo river, for instance, is twenty-four feet below the level of the Mississippi in the middle of the district; it consequently has its own basin.

That there would be some objections and difficulties connected with any plan that pretends to hold back the mighty floods of one of the greatest rivers of the world, is not surprising. The nature of the soil and the great force of the river currents leads often to a destruction of the levees by a caving of the river banks.

The flood level, in some localities, will be raised by the levees, in the opinion of some. That it has not yet done so can be easily demonstrated. Gauge readings, preserved carefully between 1811 and 1860, show that that the floods were lower during the later decades than during the former, and that in some localities the surface of the natural ground made by river deposits is higher than any known flood. The laws of hydraulics tell us that concentration of the floods tends to a

deepening of the channel by abrasion, and that a diffusion of the waters reduces the velocity, deposits sediment, and raises the river bed and consequently the flood level.

Notwithstanding the statements that have been made, that the river is raising its bed and flood level, principles and facts, deduced from careful study and observation, prove conclusively that these statements are untrue.

The statement often made, that the increase of sediment carried to the gulf since the construction of the levees has hastened the prolongation of the river into the gulf and thus raised the water at New Orleans, by corrections which the slope undergoes, is true; but when we consider that it will require five centuries to raise the flood level one foot from this cause, the practical nature of the objection is removed.

Having shown that the reclamation must be made by levees alone, it remains to consider the progress that has been made up to the present tlme in levee construction, and the national character of the work in the future.

For the information on this subject, as well as on the subjects already treated, we are largely indebted to Humphreys and Abbott's book on the Physics and Hydraulics of the Lower Mississippi, and recent official reports from Congress on the subject of Levees.

The expenditure during the last century and a half, covering the history of Levees in this country, is about $50,000,000, with 2,500 miles of levees built, such as they are.

Some of this expense was incurred in the repairing and rebuilding of levees washed and destroyed by the river.

The amount required to perfect the levee system is $36,000,000: this will effect an absolute and entire security to the whole delta.

It needs no argument to show that the States in which this work is to be done, are not able to meet this expense.

Is, then, the work of sufficient national importance to justify the Federal Government in assuming the construction, demanded by a perfect system of the levees of the whole delta.

The nation that assumes the care of the harbors and the navigation of the river — should attend to the maintenance of the banks of a river, which is a national highway and the natural outlet of the commerce of sixteen States of the Union.

Not to enter into the details of the argument or to show the sources from which the minor facts are drawn — it will be sufficient to make the following brief statement which can be verified by detailed facts.

The reclamation, thorough, permanent, and general, of the 38,000 square miles of the delta will enable us to save annually in gold $60,000,000 from sugar alone, which is now paid for imports, besides the help given to home manufacturers and machinists by large purchases of tools and mechanism, for our sugar mills.

The 10,000,000 acres of reclaimed cotton lands will yield us $400,000,000, at the present price of cotton.

In other words, with the levees perfected, we will have *added* at least $400,000,000 to the yearly products of our soil—saving an annual import of $60,000,000, and giving us an additional export of at least $350,000,000, with enough left for our home supply.

From this will come speedily what the whole country so much needs, a revival of the cotton manufacturing interests of New England, an easy return to specie payment, a balance of trade in our favor, the payment of the national debt, and the decrease of taxation. That constant steady drain from us to Europe of the precious metals, which has been of late years so great, and has resulted in the undermining of our national finances, will be turned once more the other way.

We therefore conclude—

1st. That of all the plans proposed or attempted for reclaiming the Delta of the Lower Mississippi from overflow, the only practicable plan is by thoroughly perfecting the levee system.

2d. That the States in which the delta lies cannot complete the work.

3d. That the work is eminently national, and that a great nation released from all duties, but those of peace, good will, civilization, and the promotion of national wealth and industries can find no nobler work than the rescue from the floods of the grandest area of fer tility which the Almighty ever created for man.

E. L. C.

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How to Draw a Meridian Line.—On a horizontal surface set in a fixed position in the open air, strike out with a compass three or four concentric circles at convenient intervals, at the centre erect a piece of straight wire perfectly vertical; mark the place where the extremity of the shadow of the wire in the sun passes over the circumference of the same circle before and after noon; join these points with the centre. The line which bisects the angle at the centre will be a meridian line pointing exactly north and south. The object of several circles is lest a cloud might interfere with the required observation.

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The atmosphere is universally acted upon by three forces: gravity, elasticity, and centrifugal force, this latter force being caused by its revolution with the earth. The forces gravity and elasticity diminish as we recede from the centre of the earth, while the centrifugal force increases, and consequently there is a place where the three forces balance, which is therefore the limit of the atmosphere. This has been found to be 33 miles from the surface of the earth.

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In syphons, if the liquid exterior thereto be denser than that in the interior, the flow will be reversed, and take place from the longer to the shorter leg. There being but little difference in the density of most liquids, this phenomena is rarely witnessed; but in vapours it frequently takes place, and is often manifested in chimney flues and artificial ventilation.

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Practice has proved that wind having a velocity of 10 miles per hour, is scarcely powerful enough to drive a wind-mill working a corn-mill, but when the velocity increases to double the amount, it is necessary to furl the sails. A wind, however, with a velocity of 20 miles per hour, is considered the most efficient in navigation.

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Where coal is dear, iron and skilled labor both expensive, a roughly constructed wind-mill will often be found the most advantageous machine to apply under the circumstances, notably for grinding corn, but also for raising water for irrigation and drainage purposes.

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"Dry rot" is a species of fungoid growth in timber, produced by its being continually kept under the influence of stagnant, warm, damp air. "Wet rot" is produced by the decomposition of the sap still remaining in the pores of imperfectly dried timber.

## *IRRIGATION IN INDIA.*

(I).

The resources from which the information given in these articles is compiled, are the following:

1. The minutes, despatches, and correspondence on the subject between the Secretaries of State for India and the Government of the various provinces of India.
2. The printed Parliamentary papers containing correspondence about the Madras Irrigation Company, and the East India Irrigation Company.
3. The East India Progress Report for 1872–73, under the heading "Irrigation," which though scanty in details for that year, is bountiful in a general *resume* of the past.
4. A compilation of Indian hydraulic and other statistics collected by an English civil engineer, published by Gantz, Madras, 1872.
5. A pamphlet entitled "Irrigation in India," printed at Allahabad in 1869.
6. The results of personal inquiry and experience for several years in all parts of India, and examination of local records and correspondence, as well as of the works themselves.

From these there can be no doubt whatever that in former times under native rulers, large tracts of country were very extensively irrigated. Commencing with the basin of the river Indus and the Punjab, there was an extensive system of well irrigation and of inundation canals. The district of Multan, between the Sutlej and the Chenab, where rain hardly ever falls, was a succession of beautiful gardens shaded by date palms, the corn and fruit abundant; the Afghan rulers, left by Aurunzeb, developed this to such an extent, that one of them cleared for himself from them a private fortune of nearly a million pounds sterling. There were also other innundation canals in Gugaira and other districts of the Bari Booab above Multan, of these the Kanwah and Sohag canals are best known, and Muzaffargarh, between the Ghenab and the Indus, the land under the influence of which was one sheet of cultivation. In the Shahpur district there were several inundation canals drawing their supply from the Jhelum. In the Derajat, on the right bank of the Indus, there were 12 inundation canals, having an aggregate length of 291 miles, running parallel to the Indus, and filling themselves from it in the period of annual inundation. The native state of Bahawulpur, on the south side of the river Sutlej, was also partly irrigated by inundations. In fact, in former times such canals were conducted from all the five rivers of the Punjab, traces of them, and the ruins of cities and villages on their banks, being still visible; ravines and water courses of smaller rivers or their branches, that are now dry, or have had water diverted from them either by natural processes, or by want of repairs or proper maintenance, were formerly used for conducting water for irrigation, which was then raised from them on to the fields by means of Persian wheels. It is of course quite impossible to determine the acreage then under irrigation; it was probably a very high percentage of the cultivatable area, but there is no doubt that some of these canals were large, notably those from the Chenab, named the Minchin-wah, Barus-wah, and the Sadik-wah, which were channels 100 ft. to 200 ft. wide. The immense numbers of ruined canals of different sizes all over the Punjab and Bahawlpoor, cannot fail to produce to the imagination a most flourishing and populous country of the past; and when too, we find that these natives kept also their towns well supplied with water, fountains, tanks, and baths, as may be discovered by examination of traces and old ruins in Lahore, Amritsir, Delhi, Kurnal, and countless other towns, we cannot but feel mortified as well as astonished at the inferiority and paucity of similar results under British rule.

In Sind, the country lying on the lower 450 miles of the river Indus, inundation canals were formerly both numerous and important; they varied in size up to 100 ft. in width, 10 ft. in depth, and 80 miles in length before branching off into smaller canals. Those positively known to have existed on the western bank of the Indus are as follows: The Sind canal, having its offtake 21 miles below Sakkhar, 66 miles long, before dividing itself into three branches, the Mutti, the Kadu and the Mihshuda. The Ghar or Larkhana, leaving the Indus 23 miles below Sakkhar, and having three heads or channels of supply; this is very tortuous, and eventually divides itself into two canals, the Nurwah and the Nowrung, which again sub-divide themselves. The Western Nara canal leaves the Indus 27 miles below Sakkhar, and returns to it at Sehwan; at 40 miles from the head it is 200 ft. to 300 ft. wide; the country is well cultivated on either side of it, and the villages are numerous. The Bigari canal had a total length of 48 miles with a fall of 35 ft.; the head was on a side channel, 7 miles from the Indus; it was 24 ft. wide and 9 ft. deep at the head in 1844, but then much reduced from its original size. For the first 23 miles it passed through a country covered with scrub, but presenting frequent traces of former cultivation, for the remainder of its course water was taken from it by means of Persian wheels; its principal branch was the Nurwah canal, entering far into the desert north of Khangarh.

On the eastern side of the Indus, the principal ancient canal was the Eastern Nara, called the Puraun in its lower course; it irrigated a large tract of country, part of the great Thar or Indian desert, sometimes spreading itself into the lakes, of which there were as many as 400. There was also the Fullali canal, the main feeder of irrigation channels from Haidarabad southward and eastward; originally it was a natural branch of the Indus, joining it again at a point 16 miles below Haidarabad, but the Amirs diverted the water by a dam, sending it to supply the Gaja, the Guni, and other canals to the south; the chief portion thus fell into the Guni after a course of 40 miles, the average width being no less than 350 ft. In the north-west provinces, or what is called Hindustan proper, the Emperor Firuz Shah constructed the Western Jumna canal, conducting water to Hissar; a branch from this to Delhi was made by Ali Murdan Khan, under the order of the Emperor Shah Jahan, in 1626; it crossed the lowland by a masonry aqueduct, crossed the Aravalli hills in a rock-cutting 60 ft. deep, and flowed through the city in a masonry bed, throwing off innumerable smaller streams. The great halls and courts of the palace, the fountains, marble baths, reservoirs and gardens, were supplied by numerous channels from it. This state of things lasted for 150 years, until the year 1753. Ali Murdan Khan also constructed another canal in the Dooab, east of the Jumna, under

the Emperor Shah Jahan in 1650; it was neglected and fell into disrepair, but was restored in 1764 by a Rohilla chief, Zabitha Khan. In the neighborhood of Delhi is a chain of natural lakes or jhils, the principal of which were the Najafgarh and the Kotida; these, collecting the drainage of the slopes from Delhi to Budshahpur, were formerly employed in the irrigation of the country around and below them.

Besides these works, an examination of the ruins of Old Delhi, better known as Toghlukabad, about 10 miles from New Delhi, or Shahjahanabad, shows remains of a canal, of extensive reservoirs, made or walled with concrete and cut stone, and undoubted traces of a complete system of irrigation and water supply. The magnificence of the beautiful ruins of immense tombs, mosques, palaces, halls, markets, and pleasure gardens with fountains and water channels in exquisite taste, prove that this must have been on a large scale. A careful examination of the whole of the portion of country on the right bank of the Jumna below Delhi, and a certain part of that on the left bank, shows that there must have been an immense number of tanks or artificial reservoirs, probably one or two near each of the large villages, from which irrigation was carried out. The traces of these are for the most part entirely obliterated, but enough remains to show what must have been the state of the North-West Provinces as regards Irrigation under native rule. In Rohilkhund water was obtained by damming up the hill streams, and leading small canals from them over the country; in 1824 there were 1930 dams and 915 canals; all the country between the Ramgunga and the frontier of Oudh is intersected by hill streams, from whence canals could have been, and probably were led. As to Bundalkhand, there is no record of what was done in the olden time, though probably a careful examination by an experienced hydraulic engineer might discover many traces of irrigation.

In Rajputana large reservoirs still exist, others have gone to ruin, and barely show their traces; these are more especially in Jaipur, Udaipur, Jesalmir, Bhurtpur, and Alwar. As to the large province of Bahar and Upper Bengal, there are unfortunately no records of former native irrigation; the province of Orissa, inhabited by a particularly slow and indolent race, probably had comparatively little native irrigation. The forementioned provinces may be said to comprise the whole of Northern India; Southern India, which includes everything south of the Vindhya Range, or the general latitude of the courses of the rivers Narbada and Mahanadi, has features peculiar to itself as regards irrigation, depending on the general formation of the country; this consisting generally of large plains having a very gradual fall from the Western Ghats to the Coromandel, admitted of tanks and reservoirs being made on a very large scale; these are therefore very numerous in certain districts, and occasionally are very large. Taking the provinces in order going southward from the Narbada, the Central Provinces and Berar have a comparatively small number of old works of irrigation, although a fair number of ruined tanks of a small size still exist, and there are undoubted traces and traditions of some few dams. The towns of Akola, Ellichpur, Burhanpur, and others were once well supplied with water. In Nimar, Kandeish, and the Bombay Presidency there were still fewer of these, the falls and form of the country being unfavorable on the whole, the rivers having but a slight slope, and the transverse slopes of the valleys being so great as to prevent canals from them from getting to a sufficient distance from the parent stream. In the large native state of Haidarabad, the eastern and southern portions have a large number of tanks, some of them rather large. The city of Haidarabad has a large artificial lake, called the Hosen Sagar, close to it, and the city of Aurungabad has the remains of a very extensive system of water supply, the water for which came from several distant sources; of this one channel driving a very primitive turbine and supplying a large fish pond, still exists. In the fourteen districts of the Madras Presidency there are 43,000 native tanks, with about 30,000 miles of embankments, yielding a revenue of one and a half million pounds sterling, yet up to 1853 the English had not made one, although many had been allowed to fall into disrepair.

In Mysor there must have been a very large number of them besides these; the waters of the rivers in Mysor were utilized by means of dams and channels. Some are very large; the Viranum tank has an area of 35 square miles, and a dam 12 miles long; the Chembrumbakum tank has a dam 3 miles long, and irrigates 10,000 acres of rice cultivation; the Kaveri-pak tank has a stone reveted dam 4 miles long, and irrigates 7700 acres. In the Krishna district there is a dam of stone 3750 ft. long, and 305 ft. broad, with canals from it on each bank; the English acquired the Krishna delta in 1766, and did nothing for it for 80 years, while famine periodically devastated the land; in 1833 not less than 200,000 people out of about a million, died of hunger, and the Government lost nearly one million pounds sterling of revenue. In the Balari district the rajahs of Vizianagur constructed dams and canals from the river Tugabudra in 1521, nine dams, and 89 miles of canal; the city of Vizianagur with its suburbs was formerly also plentifully supplied with water. The Great Kaveri dam, of solid stone, 1080 ft. long and 40 ft. broad, was constructed 1600 years ago. In Tinnavelli there were formerly a large number of dams and canals from the river Tambrapurni, many supplying tanks.—*Engineering.*

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VIRGINIA NAVIGATIONS.— Some Government engineers have been for some time engaged in making a survey for a canal from the James to the Appomattox in order to shorten the line of navigation between Richmond and City Point, Virginia. The engineers have made surveys from Richmond to Trent's Reach *via* Dutch Gap, and at the last dates they were advancing from the last named point to the Appomattox.

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PENNSYLVANIA RAILROAD.— Improvements which have been carried out by the Pennsylvania Railroad Company on the Newark (New Jersey) meadows will afford standing room for more than 3000 cars. There is capacity for the storage of 8000 tons of coal, and engines of trains can be coaled in from 30 seconds to 1 minute. Already about $1,500,000 have been spent by the Pennsylvania Railroad Company at this point.

## *FOUNDATIONS.*

Through the courtesy of Mr. L. P. Morehouse, the Secretary to the Civil Engineers' Club of the Northwest, we are enabled to publish the interesting and eminently practical paper following, which was written by Wm. Bryson, Civil Engineer, and read by him at the Club, on the 11th July, 1870.

An advance has of course been made since that time in some parts of the practice of which the author treats, notably in the case of the employment of the *plenum* process in sinking piers for foundations, of which the greatest examples are those of the St. Louis Bridge and East River Bridge, N. Y.; but from its interesting character we publish the paper below almost in its entirety, as it was written.

After a few preliminary remarks, the author says:

"The foundations of a country's civilization is a system of good roads, whether they be railroads or common country roads. Roads are the veins and arteries by means of which the circulation of the social body is carried on; where they do not exist there can hardly be said to be a community —the people have nothing in common, no commerce nor intercourse of any kind unites them. The inhabitants of a country without roads would of necessity be nearly like savages.

It is well known that the Romans constructed with great solidity, and maintained with constant care, roads diverging from the capital to the extremities of the empire. The good condition of these was thought to be of such importance, that the charge was only entrusted to persons of the highest dignity, and the Emperor Augustus himself, assumed the care of those in the neighborhood of Rome. The expense of their construction was enormous, but they were built to last for ever, and to this day remain entire and level in many parts of the world, where they have not been exposed to destructive violence.

They usually were raised some height above the ground which they traversed, and proceeded in as straight a line as possible, running over hill and valley with a sovereign contempt for all the principles of engineering. They consisted of three distinct layers of materials; the lowest or foundation, stones mixed with cement, *statumen* (meaning, that which supports anything); the middle, gravel or small stones, *rudera* (meaning rubble, rough stone or broken pottery); to prepare a level and unyielding surface to receive the upper and most important structure which consisted of large masses accurately fitted together.

The foundation, *statumen*, was composed of one or two courses of large flat stones laid in mortar, a bed of which was first spread over the earth; next came a course of concrete, *rudera*, formed of broken stones mixed with quick lime and pounded with a rammer; the third course, *nucleus*, was composed of broken bricks, tiles and pottery, mixed with lime which formed ¼ the whole. The mixture was spread in a thin layer, and in it were imbedded, so that their top surface were perfectly level, the large blocks of stone, *summa crusta*, which formed the pavement; the entire thickness of the four strata was about three feet. The pavement consisted of large hard polygonal blocks of stone, usually with 5, 6, or 7 sides, composed principally of basaltic lava, and so perfectly fitted together that the joints were scarcely perceptible. The natural obstructions in forming those roads were great; rocks had to be cut through, valleys filled up, ravines bridged, and swamps embanked.

A continuous roadway existed from the wall of Antoninus in North Britain to Rome, and thence to Jerusalem, a distance of 3,655 miles, exclusive of a sea passage of 85 miles. The wall of Antoninus was a barrier erected between the Firths of Forth and Clyde by the Romans in the reign of Antoninus Pius. The work consisted of a ditch about 20 feet deep and 40 ft. wide, a rampart of earth and stone about 20 feet high and 24 thick at base, and on the inner or south side of the rampart a paved military road; it is commonly designated "Graham's Dike."

The chief approach to Pompeii was through Naples and Herculaneum along a branch of the Appian way. The Via Appia one of the twenty-nine roads which diverged from the Imperial City was well named by an ancient writer, Regina Viarum (the queen of roads), and was made, in part at least, by Appius Claudius Cœcus, while he was Censor, B. C. 313. It is the oldest and most celebrated of all the Roman roads, and led from the Porta Capena, in a southerly direction, to Capua, passing through Three Taverns, Appii Forum, Terracina, &c.; subsequently it was carried on to Beneventum, Tarentum, and thence to Brundusium; it had an admirable substructure or foundation, from which all the loose soil had been carefully removed; portions of it are still in use, and the remains are visible all along its route, especially at Terracina.

It is curious to observe that after many years' experience of different methods of imperfect paving in London, they have returned to the same plan as the Romans. The pavements of Cheapside and Holborn, &c., is based in the same way, upon broken granite instead of loose earth or sand which constantly works through the joints and vitiates the solid bearing which the stones should possess. A further security against its working into holes is given by dressing each stone accurately to the same breadth, and into the form of a wedge, like the voussoirs of an arch, so that each tier of stones spans the street like a bridge; this is an improvement on the Roman system, as the Romans depended for the solidity of their construction on the size of their blocks which were irregularly shaped, although carefully and firmly fitted.

The great wall of China, whose whole length with all its windings, is computed at 1,500 miles, runs over mountains 5,000 feet high, across valleys, rivers and marshes, and along sandy hollows which seem incapable of admitting a foundation for such a weighty structure. It is a structure of earth retained on each side by solid brick work, and terraced by a brick platform furnished with parapets. The total height of the masonry is 25 feet, the base is of granite, projecting about 2 feet beyond the brickwork, the height of which is irregular; the thickness of each retaining wall is about 5 feet, and the entire thickness of the work is 25 feet; the bricks used in the construction are kiln-dried and well moulded, and are cemented by a strong mortar of calcined lime.

The Campanile, or leaning tower of Pisa, is 190 feet high, entirely built of white marble, and stands not less than 15 feet out of the perpendicular. Some conceive this reclining position to be occasioned by a sinking of the foundation on one side, others to the ancient builders aiming at eccentricity, but as the observatory and baptistry which stand in the same square, have also a slight inclination, there can be but little doubt that the former is the correct opinion. The only other lofty structure known to incline so much from a perpendicular position is the leaning tower of Saragossa in Spain, built entirely of brick.

The success of the Chicago tunnels under Lake Michigan, those in this City, at Cleveland, Detroit, and London, England, must doubtless inaugurate a new era in subterranean modes of communication and will lead on to many similar enterprises (among which is the tunnel under the Straits of Dover between England and France, which as present proposed and seriously contemplated, will be 85 miles in length!).

[*To be continued.*]

I believe if the means were furnished us, that we can execute work quite as good as that of the ancients, and many of our structures will remain for centuries yet to come; we can also make roads as good as those of the Romans if we are only permitted to do so. The roads constructed under the direction of Telford produced a change in the people of the highlands of Scotland which is probably unparalleled in the history of any country for the same space of time. In this connection, notice what the Illinois Central, the various Pacific Railroads, and all the other well-constructed western roads have done; even our own imperfect and perishable wooden block pavement has already done a great deal here to the advancement of this city of Chicago.

We might compare the great masonic work on the Via Appia with the high level bridge at Newcastle, the Tweed & Boyne Viaducts, the Britannia & Conway Bridges, the Suspension Bridges at Cincinnati, Niagara and East River, the Washington Aqueduct, Victoria Bridge, the St. Louis Bridge and many other works successfully completed, too numerous, however, to mention here. Our own superiority consists more in mental power and scientific knowledge than in the mere application of unskilful labor, as in the present state of engineering, the question is not one of of difficulty but one of cost.

The best foundation is that which consists of gravel or stone; but in order to know whether the underlying inferior strata are sufficient for the support of the building, it will be advisable to sink test pits at some little distance. By attending to what is thrown up in digging these, the engineer will be acquainted with what lies under the stony or gravelly bed which on the surface promises so much security, and will know what measures to take. But though a stony or gravelly bottom is undoubtedly the most sure and firm where all is sound beneath, there is no kind of ground which may prove more fallacious or occasion such terrible accidents, as it often contains absolute vacuities; nor is rock itself, though a foundation upon a rock is strong even to a proverb, free from dangers of the same kind. Caverns are very frequent in rocky places, and should a heavy building be erected over one of these, it might suddenly fall down altogether. To guard against accidents of this kind, Palladio advises the throwing down great weights forcibly on the ground, and observing whether it sounds hollow or shakes; and the beating of a drum upon it, by the sound of which an accustomed ear will know whether the earth is hollow or not; where the foundation is gravel, it will be proper to examine the thickness of the stratum and the qualities of those that lie under it, as they have appeared in digging or boring. If the bed of gravel is thick, and the under strata of a sound and firm kind, there needs no assistance; if otherwise, recourse must be had to various methods in order to supply the defect.

The other strata which may occur for a foundation are clay, sand, common earth, or rather boggy ground. Clay will often both raise and sink a foundation; yet it has a solidity, which with proper management is very useful. The marshy, rotten, or boggy ground is of all others the worst; yet even upon this, great buildings may be erected with perfect safety, provided care be taken. In case of boggy earths or infirm or yielding sand, piling is one of the most common methods of securing a foundation; and notwithstanding the natural disadvantage of the earth, piling, when properly executed is one of the firmest and most secure foundations. In foundations near the edge of waters, care should be taken to sound to the very bottom, as many accidents have happened from the ground being undermined by rivers.

The Italians begin their foundations by laying on the natural soil, strong oak plank, and upon that they lay, with the utmost care, the first course of materials, without mortar. Whether we take this method or begin upon the naked earth, all must be laid with the most exact truth. When the plank is laid, a course of stone is the best first bed.

The thickness of foundations in general ought to be double that of the walls which they are to support; the looser the ground the thicker the foundation ought to be, and it will require the addition also in proportion of what is to be raised upon it.

We are indebted to Smeaton, for the use of cement for our foundations, who was the first to discover in or about the year 1756 that the real cause of the water-setting properties of lines and cements consisted in a combination of clay with the carbonate of lime; in consequence of having ascertained by a very simple sort of chemical analysis, that there was a proportion of the former ingredient in all the natural limestones, which on being calcined, developed that highly important quality, without which walls exposed to water go to pieces, and those exposed to air and weather only, are comparatively of inferior strength.

Concrete for foundations if judiciously applied, supersedes the very expensive, troublesome and precarious process of piling and planking, even in the softest soils. It was first first adopted by Sir Robert Smirke with success in the foundation of the penitentiary at Millbank, where the soil consisting chietly of peat moss, was soft to a very great depth. In excavating for one of the piers of the Waterloo Bridge, the workmen had a good deal of difficulty, owing to the very compact state of the soil forming the bed of the river, which everywhere else they had found perfectly loose. This effect had been produced by the accidental sinking of a large load of lime over that spot some time before, which had cemented the loose gravel into a solid mass, resembling the calcareous conglomerates of nature, which are gradually formed by a similar process. Mr. Rennie having mentioned this circumstance to Sir Robt. Smirke, the latter, with great judgment, availed himself of the hint, and subsequently used it in all his foundations, none of which have ever been known to fail. The superior efficiency of concrete was also proved in a remarkable manner at the Custom House, where the floor of the larger apartment known as the "Long Room," actually fell in, and the whole building was in danger, owing to the insufficient manner in which the piling had been originally executed in a very difficult situation. At this period, Sir Robert Smirke was consulted who found it necessary to pull down a small part of the building but saved the rest of it, by undersetting all the walls with concrete to the average width of 12 feet, and to the depth of from 12 to 15 feet, that is, until he had found a natural bed of gravel, including one course of Yorkshire landing stones and twelve courses of bricks, laid in cement having three or four offsets or footings between the Yorkshire landings resting on the concrete, and the base of the original walls. No other expedient could possibly have saved this fine building from entire demolition. Not only the ancient Romans and after them the Moors, but also the Norman Barons of England in their feudal castles, used concrete of which Kendal Castle is one of the most striking examples; and more recently, Belidor, in his 'Architecture Hydraulique,' treats of Beton Mortar which is much the same; so that it is not absolutely new, but the merit of introducing this immense improvement systematically into modern practice is undoubtedly due Sir Robert Smirke.

[*To be continued.*]

TRANS ALLEGHANY CANAL.—Col. Sedgwick, the Engineer who made the Government survey, recently stated at a convention in Pittsburg, that the projected canal was entirely practicable and would probably cost $20,000,000; though it might be made for $16,000,000.

# ENGINEER, ARCHITECT AND SURVEYOR.

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## *THE EDUCATION OF SURVEYORS.*

The lawyers and doctors who rank high in their respective professions are presumed to be thoroughly educated in most, if not all, the departments thereof. The study of Blackstone's commentaries alone will not make an attorney, and the Pharmacopœia committed to memory entire will not qualify a man to treat even the simplest diseases of the human body. If, however, a surveyor is only a land measurer,—a common laborer, hired at so much per diem to drag a chain through swamps and brush, up hill and down, and requiring only education sufficient to make figures and calculate the area of a rectangle or triangle; he does not require even one book, and to be a peer in his profession he needs only a partial acquaintance with Gillespie's excellent manual.

This is not our ideal of an educated surveyor. There is more to us in the profession than tired limbs and torn garments. There are possibilities in it worth striving for, and a niche of honor worthy of an honest ambition to fill. They are the rewards of superior knowledge, untiring industry, and a faithful and conscientious discharge of the duties pertaining to the profession.

The surveyor has a large field in which to exercise his talents before he trenches on the domain of the civil engineer. The office of the latter "consists in the designing, arrangement and construction of all works, structures, or machines, which require the immediate superintendence of a person acquainted with the principles of construction;" that of the former is to determine "the contour, dimensions, position, or other particulars of the earth's surface, whether on land or water, and to accurately delineate the same on paper." Surveying is a branch of civil engineering, and so is the construction of machines, and a surveyor is no more a civil engineer than a machinist is. The machinist must serve a long apprenticeship, and the more he knows about the use of tools and the principle of construction the better mechanic he is; so also good surveyors do not come full fledged from a six months course of study in a district school.

To be able for any emergency a surveyor should be familiar with Geometry and Plane and Spherical Trigonometry; the propositions and rules required in ordinary farm and city surveying are very few and simple, but an ambitious man will look forward to a higher practice than this, and when the time comes he must not be wanting in the knowledge necessary to his advancement. For centuries to come there will be need for trigonometry and geodetical surveys, and the best men in the profession will naturally be selected to conduct them.

To know the best instruments, and how to use them in his practice, is as necessary for the surveyor as for a mechanic to know what tools he must use to do his work most effectually and economically. There are instruments for measuring lines and angles on the ground, and others for platting these lines and angles on paper, and it is an important part of a surveyor's education to know how to correct his chain, to adjust his transit or other similar instrument, and to place on paper, with scale and protractor, a correct delineation of his work done in the field. To appreciate how deficient surveyors are generally in this last branch of their profession, it is only necessary to see some of their miserable, untidy scrawls of plats, drawn on any paper that is convenient, and to some undiscoverable scale, "inked in" with a common writing pen and ink, and embellished with letters and figures that any four year old child ought to be ashamed of. We wish we could prevail upon our county surveyors, wherever they are careless in their office work, to try and improve in this particular; to provide themselves with good instruments, and drawing paper and materials; they would soon be repaid by the sight of the neat, clean plats which would result therefrom.

How to determine the latitude and longitude of any station, to draw a meridian line, and run on a true parallel of latitude, should be known to every intelligent surveyor. He should also know enough of geology and mineralogy to enable him to describe accurately, and in correct terms, the physical features of any region which he may explore, and to report on its mineral and agricultural resources. So also he should be able to note correctly the various kind of timber, and be able to indicate their availability for the purposes of building or manufactures. The study of natural history will be of great benefit in the improvement of his observing faculties, so that he will be living in a world abounding in delights which lie all around if he might but open his eyes and mind to enjoy them.

## *FIRE-PROOF CONSTRUCTION.*

The importance of our subject can hardly be over-estimated, when we bear in mind the vast losses which take place yearly from the ravages of fire; losses of both life and property. Many still think that the chief points to be considered in erecting a fire-proof building is the selection of materials noted, or suppose to be noted, for their fire resisting properties, such as stone, iron, concrete, brick, cement, &c. We say advisedly, supposed to be noted, for experience has by this time pretty conclusively shown the utter fallacy of trusting alone to the so-called fire-proof qualities of the materials named above.

Timber has long been discarded or at least used very sparingly in the construction of fire-proof buildings on account of its well-known inflammable qualities, but the fact that under the influence of considerable temperatures iron, stone, and the poorer varieties of bricks are equally dangerous, has not as yet been recognized as fully as it ought among architects and others, whose duties include the erection of fire-proof structures. As "seeing is believing," so the converse is too generally true, and though we all have very frequently seen timber burn with but little fire or heat applied, but few of us have actually seen, nor any of us very often seen, the results of fire upon iron, stone, etc., whence arises the incredulity too often met with when designers are told by practical men that under the influence of not a very high temperature, cast-iron warps, or cracks, and shortly afterwards melts; stones crack, split or crumble into powder; and bricks of a poor quality melt or crumble to dust.

At a temperature of 600° Far. cast-iron begins to loose its strength, and if touched by the spray from the hose of the fire-engine, flies to pieces immediately; if in the form of a column, that important structural feature in a building, being one among a series as is generally the case, its fall brings the weight it supported upon the two adjacent columns already heated and, bear in mind, weakened thereby, and this generally results in the immediate collapse of the whole flooring above or other weights supported. The whole of the floors below this again fall one after the other by these extra weights thrown upon them and in a few momcnts the demolition of the whole interior of the building is completed.

To remedy this fault in cast-iron, it is not sufficient to say that the columns must be proportioned in such a manner that if one or two were to fail, the remainder should be strong enough to support the extra weight thus suddenly thrown upon them, for in fact, in all well constructed buildings, the colums *are* calculated with a factor of safety of 4 at least, that is, to bear without breaking any weight under 4 times the maximum load ordinarily placed upon them.

Wrought-iron where employed in a building is generally in the form of girders and tie-rods, both which expanding under the influence of heat soon twist and are warped in such a manner as actually to assist in no small degree the destruction of the building. The strains developed in a girder by heat are intense and of a very complex character; those in a tie-rod are naturally more simple, but it is impossible by previous calculation, to prevent in the one the twisting of the flanges or shearing of rivet-heads, and in the other the warping of the rods and loosening of the nuts.

The various elements composing the forces set in action by a conflagration, are of such an indeterminate character that it is impossible to counteract them by any previous calculation or in fact any calculation at all, and we must therefore look for some other method of successfully combatıng the attacks of a great fire than that of merely strengthening those structural portions of a building which which are made of iron.

The three classes of stones usually employed in buildings, calcarous, siliceous and granitic, act variously according to their chemical composition, in the different varieties of the same classes under the influence of fire.

Limestones calcine and are formed into quick-lime the more readily as they are the purer; sand-stones in open grained and impure varieties, split into pieces but are generally somewhat more to be relied upon in their fire resisting properties than the limestone; in the purer, close, and large-grained varieties, they are a good refractory material and are chiefly used for the hearths of blast furnaces, &c.; slates, another variety of siliceous stones, soon split up on the application of heat; granite and gneiss are both more or less refractory according to the proportions of their ingredients, quartz, feldspar and mica, but neither are as good as the coarser sandstones which are nearly pure quartz; when they do fail under fire it is by splitting into large fragments generally with a force that drives them through the air some little distance.

As a fourth constructive material bricks now come under our notice, and we may here state that if good, well-burnt in their manufacture, and set in cement they are the best material that can be used in a fire-proof building. Bricks of poor quality or ill-burnt soon crumble into powder, melt or sometimes even burn under the influence of fire even as certain porous sand-stones obtained from a shaly formation also take fire and burn from the mineral oil they contain.

Concrete may be generally considered, if manufactured

with due care as regards the refractory nature of its components, as good a material for resisting fire as brickwork set in cement, but is inapplicable from its appearance, to outside work on a building where an ornamental or elegant design both in form and color is requisite.

The various kinds of artificial stones now come under notice and though the advocates of each patent claim theirs as the best fire resisting material we have not sufficient data whereby to judge of their relative merits in this respect.

To sum up then, the various materials we have mentioned may be graded in the following order as regards their fire-proof qualities, the best being first: Brickwork set in cement; Concrete; Sandstones; Granitic rocks; Wrought-iron; Limestones; Cast-iron; Slates and Timber; the Artificial Stones are not classified for reasons above stated.

From the impossibility of a building being uniformly affected by a fire to the same degree, at the same time, we see that we cannot rely alone, in our endeavor to produce a fire-proof building, on the nature of the refractory materials used in its construction, for however excellent they may be, we cannot ensure a uniform stress being exerted upon them at the same time. The conclusion is therefore arrived at, that it is not so much in the materials used that we are to look for a fire-proof construction as in the design and arrangement of the building itself, and to this most important matter we will now turn our attention.

[*To be continued.*]

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MR. FLEMING'S REPORT ON THE CANADIAN PACIFIC RAILWAY.—At length this valuable book has appeared. It is full and elaborate. It comprises nearly 300 pages, together with maps and diagrams. The Peace River country is highly spoken of. The following is the substance of the report:—

That although the information respecting the Rocky Mountain zone is not yet sufficiently complete to establish the line to the Pacific, several routes have, however, been found on which the obstacles met with, although formidable, are not insuperable.

That there are reasonable grounds for the belief that the explorations in progress in British Columbia will result in the discovery of a line through the Rocky Mountain region, which, taking everything into consideration, will be more eligible than any yet surveyed.

That it is now established beyond doubt that a favorable and comparatively easy route, considering the line as a whole, has been found from Ottawa to the northerly side of Lake Superior. This result is the more satisfactory, as an unfavorable impression has been created regarding this portion of the country, many having considered it even impracticable for Railway construction.

That it will be possible to locate the line direct from the northerly side of Lake Superior to the prairie region without unusually expensive works of construction, at the same time with remarkably light gradients in the direction of the heavy traffic.

That the main line from Ottawa to Manitoba can be located in such way as to render unnecessary the construction of a branch to reach the navigation waters of Lake Superior.

That there will be no difficulty in finding a comparatively easy route across the prairie region.

That the bridging of the large rivers, with proper care in location, will form no large proportion of the cost of the whole extent of the Railway.

That with respect to operating the railway in winter, the chief difficulties will be found on the western slopes of the two great mountain chains in British Columbia, but except in these localities, the Canadian Pacific Railway will have on an average considerably less snow than existing railways have to contend with.

That the practicability of establishing Railway communication across the continent wholly within the limits of the Dominion is no longer a matter of doubt. It may indeed be now accepted as a certainty that a route has been found generally possessing favorable engineering features, with the exception of a short section approaching the Pacific coast, which route, taking its entire length, including the exceptional section alluded to, will on the average show lighter work and will require less costly structures than have been necessary on many of the railways now in operation in the Dominion.—*Perth Courier.*

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## *ANSWERS TO CORRESPONDENTS.*

MR. EDITOR.—[1]. A man has a *patent* calling for the W. ½, N.W. ¼ of Sec. 6, containing 70-4 acres according to the plat of the government survey; another man has a *deed* calling for the E. ½, N.W. ¼ of same section, containing 80 acres, *more or less*; if the N.W. ¼ be 40 chains, north and south, must not the first man have his 70.4 acres whether the quarter section be larger or smaller than the original survey supposed?

[2]. There are two deeds; one calling for the N. W. ¼, of N. W. ¼ of Sec. 6 containing 38 acres more or less; the other calling for the S. W. ¼, N. W. ¼ same section, containing 40 acres more or less, how are the above to be divided? E. B. O. Co. Surveyor,

ANS.—[1]. Each man must get exactly one half of the quarter section no matter what area his patent or deed calls for. The presumption is, that 70.4 acres is very nearly the area of each half; the term "80 acres more or less" is a very indefinite one, and has no weight in determining the survey.

ANS.—[2]. Give to each that part of the section that his deed calls for without reference to area.

MR. EDITOR.—Where the Gov. ¼ stake is not in the center between Sec. corners, is the County Surveyor to be governed by it or will he proceed to make a center in order to make a Subdivision. It is of importance to me to know what the decisions are on this point. J. H.

ANS.—The government corner in every case, where well authenticated, must stand. No private surveyor has the right to correct them.

See paragraphs 44, 45, 46 of Law and Legislation.

MR. EDITOR.—Why does the end of the needle in a compass fly up and adhere to the glass when the upper surface of the glass is rubbed by the hand on a warm day? M. F. M.

ANS.—The rubbing of the glass induces electricity. When a stream of electricity passes over a steel needle or a bar of iron, it produces a certain modification in its magnetic state. If the needle be in its natural state it is rendered magnetic. If it be already magnetic, its magnetism is modified, being augmented or diminished in intensity, according to certain conditions depending in the direction of the current, and the position of the magnetic axis of the needle. A proper understanding of the phenomenon requires an acquaintance with the subjects of Voltaic Electricity and Electro Magnetism.

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MR. EDITOR, WAUKEGAN, ILL., June 10th, 1874.

Your correspondent, J. M., of Shawano, Wis., under date of April 25th, 1874, asks your opinion of the proper method of subdividing fractional sections.

Your answer, I think, does not cover the whole ground. By Act of Congress, approved Feb. 11, 1805, sec. 2, the law is laid down, that "in those portions of the fractional townships where no opposite corresponding corners have been or *can be* fixed, the lines shall be ascertained by running from the established corners due north or south, east or west. If the opposite corners can be fixed by closing the survey of the section and establishing the opposite corner by the same rule used by the Government surveys," as it may frequently be done by closing the survey in winter, on the ice, I think it should be done. *Theoretically*, the interior lines are run parallel with the *south*, and east lines of the township. As the Government surveys were not required to conform *literally* to the rule to run *due* N. and S., E. and W., so, in subdividing sections, it will not do to apply the rule *strictly*. As the subdivision of a township is commenced on the E. and S. line, I think a fair construction of the rule to be, to run parallel with the E. or S. line of the section, or perhaps it would merely conform to the rules, to run the *interior* lines of *interior* sections by *intermediate* courses, and those of the north and west tier of sections by the other rules. I would like to have the opinion of others. H. W.

## *LAW AND LEGISLATION.*

An abstract of decisions of the Supreme Court of the United States and of the courts of the various States in the Union upon questions relating to boundaries, surveys, etc.

31. Where land is described as running a certain distance by admeasurement, to an ascertained line, though without a visible boundary such line will control the admeasurement and determine the extent of the grant. Flagg v. Thurston, 13 Pick. (N. Y.), 145. See Carroll v. Norwood, 5 Har. & J. (Md,), 163. Bates Tymason, 13 Wend. (N. Y.), 300.

32. Where the lines or courses of an adjoining tract, being sufficiently established, are called up in a patent or deed, the lines shall be extended to them without regard to distance. Cherry v. Slade, 3 Murph. (N. C.) 82.

33. Where the patent calls for the lines of another patent, it must stop at the first intersection with the latter. Bradberry v. Hooks, 2 Taylor (N. C.) 1,

34. Lines actually marked must be adhered to, though they vary from the course. M'Nairy v. Hightour, 2 Overt, (Tenn.), 304. Newsom v. Pryor, 7, Wheat. 7.

35. The marked trees according to which neighbors hold their distinct lands, when proved, ought not to be departed from, though not exactly agreeing with the descriptions of boundaries in the conveyances. Herbert v. Wise, 3 Call. (Va.), 239. See Baxter v. Evett, 7 Monr. (Ky.), 333.

36. A line actually marked for the survey, is to govern the boundary, although not a right line from corner to corner. Where a line has been marked only part of the way, the boundary for the residue of the distance should be a direct line from the termination of the marked line to the corner called for. Cowan v. Fauntleroy, 2 Bibb. (Ky.), 261. Thornberry v. Churchill, 4 Monr. (Ky.), 29.

37. If the plans and the monuments made by an original survey of a tract of land do not correspond, the monuments are to be resorted to, in order to ascertain the true location. Esmond v. Tarbox, 7 Greenl. (Me.) 61.

38. And if the monuments were made by one Surveyor, and the plans drawn afterwards by another, and the plan alone is referred to in the Conveyance, yet the monuments control and govern the plan. *Same case* 7 Greenl. 61.

39. If a patent refer to a plat annexed, and if in that plat, a water course be laid down as running through the land, the tract must be so surveyed as to include the water-course, and to conform, as nearly as may be, to the plat, although the lines, thus run, do not correspond with the courses and distances mentioned in the patent; and although neither the certificate of survey nor the patent calls for the water course. M'Iver v. Walker, 4 Wheat., 444.

40. Where a survey is referred to in a deed, the grantee takes in conformity thereto, although the boundaries mentioned in the deed would naturally exclude the land included in the survey. Lunt v. Holland, 14 Mass. 149.

41. Where lots have been granted, designated by number, according to a plan referred to, which has resulted from an actual survey, the lines and corners made and fixed by that survey are to be respected as determining the extent and bounds of the respective lots. Pike v. Dyke. 2 Greenl. (Me.), 214.

42. Where the call in a certificate of survey is to a tree, as the beginning tree of another tract of land, the party need only prove it to be the tree called for, and is not obliged to prove also that it is the beginning or other tree of the land of which it is described to be a boundary. Boreing v. Singery, 4 Har. & McHen. Md., 398.

43. Where a survey has been made on a warrant, and returned, calling for an adjoining survey, as one of its boundaries, the title of the warrantee will extend to such adjoining survey, although the line actually run and marked on the ground may be a few perches from the line of such adjoining survey. Martz v. Hartley, 4 Walsh (Pa.), 261.

44. The United States in providing for the survey of the public domain, established the rule, that sections of lands should be held to contain the exact quantity returned by the Surveyor General; so that the corners of sections fixed by such survey, cannot be removed. Walters v. Commons- 2 Porter (Ala.), 38,

45. In the case of sections, the government has arranged their boundaries, marked their lines and corners, and declared the contents; and the purchaser of an entire section takes all within those limits, be it more or less than the quantity returned by the surveyor, but in the purchase of a *less* quantity than a section, (as between the several holders of a section.) the contents of such several parts must be determined by reference to the entire section; and the purchaser of a half or quarter section is entitled to one half or one quarter of whatever the section contains. In such case, the half mile posts or corners are to be placed equidistant between the corners of a section, for the half mile posts are not definitively fixed by law, as in the case of section corners. Walker v. Commons, 2 Parker (Ala.), 38.

46. But where the objects are fixed by law for the corners of quarter sections, and can be found, they must determine the boundaries. Johnson v. Gresham 5, Dana. (Ky.), 543.

47. The line of an elder survey will prevail over those of a junior survey, where they interfere with each other. Dorsey v. Hammond, 1 Har. & J. (Md.), 201.

48. The proprietors of land bounded on a highway have, *prima facie*, at least, a fee in such highway, to the middle line of the road, subject to the easement. Chatham v. Brainerd, 11 Conn., 60.

49. But where a deed of land describes it as bounded on a road and sets forth metes and bounds which plainly exclude the road, no part of the soil and freehold passes by the grant. Tyler v. Hammond, 11 Pick. (Mass.) 193. Jackson v. Hathaway, *ante*.

50. Tenants in common of land, traversed by a town road, exchanged deeds of partition, in which the land was thus described—"Beginning at a stake and stones on the south side of the town road," &c., "thence by various courses, to said road, thence, by said road, to the place of beginning." Held that the portion of land covered by the road did not pass, but the tenancy in common continued, subject to the easement as before. Sibley v. Holden, 10 Pick. (Mass.) 246.

51. Where a deed, patent or grant, describes a boundary from a certain point down a river, the river should be considered the true boundary, though the course and distance are given, and they do not follow the river. Harramond v. M'Glaughon, 1 Taylor (N. C.), 136. Reed v. Langford, 3 J. J. Marsh. (Ky.), 430.

52. A call, in a grant from a bound on a river, "west up the river to a stake," is in law equivalent to "with the river," and the line must pursue the course of the stream. Den v. Mabe, 4 Dev. (N. C.), 258.

53. "Thence down the swamp" was held to mean "along the swamp." Hartfield v. Westbrook, 1 Hayw. (N. C.), 258.

54. Where an ambiguity as to the location and boundaries of land exists on the face of a deed, the court may allow evidence *dehors* the grant to go to the jury, and this is a proper matter for their consideration. Dorsey v. Hammond, v. Har. & J. (Md), 201. Hembree v. White, 2 Overt. [Tenn.] 202, Baker v. Talbott, 6 Monr. [Ky.], 182.

55. To prove the location and survey of a tract of land calling to begin at the end of one of the lines of another tract, and to run to and intersect other tracts, &c., and that it began at and run to particular places described on the plats, parol evidence of the surveyor who originally surveyed and located the tract of land, was admitted as legal and competent. Tenant v. Hambleton, 3 Har. & J. [Md.], 233.

56. Wherever it can be proved that a line was actually run by the surveyor, was marked, and a corner made, the party claiming under the patent or deed shall hold accordingly, although there is a mistaken description of the land in the patent or deed. Cherry v. Slade, 3 Murph. [N. C.], 82.

57. Where corners are lost, they may be proved by reputation; witnesses may be examined to show a corner once existed, that it has been destroyed, and that it corresponded with the call of the entry or survey. McCoy v. Galloway, 3 Ham. [Ohio.], 283. See Storer v. Freeman, 6 [Mass,], 441.

## *CIVIL ENGINEERS' CLUB OF THE N. W.*

The annual meeting of this society took place on the 8th inst. These annual meetings have heretofore been accompanied by a dinner or supper in the City, but on this occasion it was wisely decided to charter a steamer for an excursion upon Lake Michigan and issue card of invitation to the wives and families of the members and their friends.

At 2 p. m. therefore a goodly company of both sexes. assembled on board the "Muskegon," and shortly after that hour the boat started for the "Crib," the point where the water is taken from Lake Michigan for the use of the City of Chicago; this also being the point where the operation of drifting the new Lake Tunnel from the "Crib" toward the shore is carried on.

On arriving at the Crib, the members and visitors were allowed every opportunity of inspecting the works in progress although the time was somewhat limited. A few data regarding the works in progress will be of interest to our readers.

It was decided last year to increase the water supply of the City of Chicago, and for this purpose two new tunnels were designed; the one to take the water from the lake to the "Crib," and convey it to the pumping station on Chicago avenue; the other to carry the same from the pumping station to the junction of 22nd street and Ashland ave., in a southwesterly direction; this last tunnel crossing under the Chicago River in two places.

Operations were commenced simultaneously (after the test borings), on the shore ends of the Lake and City Tunnels, at the "Crib" end of the Lake Tunnel, and in sinking various shafts along the line of the shore tunnel.

The workings disclosed throughout the same nature of materials as were encountered in the drifting of the first tunnel in 1867–8; a dark blue clay, generally dry, with occasional pockets of sand, and cavities filled with gas of an inflammable nature. Size of the headings, 9 feet diameter, of the tunnel when finished, 7′ 2″ high × 7 ft. wide (inside measurement), with walls 12″, or 1½ bricks thick laid in hydraulic cement mortar. As we hope to publish, shortly, a full description of all the tunnel works in progress, data concerning the operations at the "Crib" alone are here given.

The miners work in 8-hour shifts and excavate from 18 feet to 20 feet forward per diem; on an average, 12 miners excavate 20 ft. in 16 hours, and 3 masons lay the brickwork for the same in 8 hours. At the time of the visit, the face of the work was, about 1060 feet from the hoisting shaft. The "trollies" or wagons containing the excavated "dirt," are run along rails 23″ guage, by men, to a platform in the hoisting shaft where they are lifted a height of 118 feet to the dumping platform, on which they are run out until above the water on the east side of the Crib where the material is dumped.

The hoisting apparatus consists of a platform supported by a ⅞″ wire rope passing over a 4 ft. wheel and attached at the other end to the winding drum, 3′ 6″ diameter, which through gearing is driven by a neat little horizontal engine with cylinder 12″ dia., 18″ stroke; the boiler pressure being 40 lbs. The work on the Lake Tunnel will be completed during the first week in July.

A stone wall with brick lining has lately been built round the Crib instead of the former timber work, 8 feet thick, the brick lining 3 bricks or 2 feet thick, the stonework 6 ft. thick.

From the Crib the "Muskegon" steamed in the direction of South Chicago as far as time allowed, returning to the wharf at 5.30 p. m., after an excursion which will be reckoned by each one of the party as one of the pleasantest afternoons spent in the course of the year.

On leaving the Crib, the Annual meeting of the Club took place, E. S. Chesbrough, Pres., in the chair, supported by L. P. Morehouse, the indefatigable Sec. and Treas. The reading of the minutes of the last meeting were dispensed with, after which Mr. W. H. Clarke was ballotted for and declared duly elected as member, and Messrs Geo. H. Frost and Chas J. Moore were proposed for membership to be ballotted for at the next meeting. Donations received since last meeting, four photographs of the Louisiana Bridge, Mo., from E. L. Corthell, C. E., and Illustrated Album from the Keystone Bridge Co. The Sec. then read his annual Report from which it appears that 11 meetings have been held, 7 new members and 2 associate members elected, and the following papers read: Resistance to Traction on Railroads. by R. J. LcLure; Spiral Motion in Nature, by J.. R. Straughan; On the Conveyance of Water and the Repairs of Pipes under navigable streams, by E. S. Chesbrough; Harbor Improvements on the Lakes, by Col. D. C. Houston; Leveeing on the Upper Mississippi, by E. L. Corthell; On the Preliminary Surveys for the Texas & Pacific Railroad, by C. W. Durham; Test Borings and a Tool for making them, and Record of Caisson Disease at Lake shaft of New Water Tunnel, Chicago, by E. C. Clarke; Jurisprudence of Surveys, by S. S. Greeley; Rigid Suspension Bridges, by C. J. Quetil; Concerning the cost of Transportation on Railroads, by L. P. Morehouse. The financial position of the Club as set forth in the Secretary's Report was very encouraging.

The President then read a short address to the Club in which he urged the necessity of a better attendance of members than heretofore, and the great use and benefits of discussion on the various papers read.

Officers for the ensuing year were then elected, the ballot resulting as follows; Pres., E. S. Chesbrough, Sec. and Treas., L. P. Morehouse, Executive Committee, H. W. S. Cleveland and C. W. Durham. The Executive Committee were then authorized to report on the proposal to provide new rooms for the Club meetings, and on the publication of the papers, and after a cordial vote of thanks to the President and Secretary, the proceedings terminated and the meeting adjourned until the second week in September.

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NORTHERN PACIFIC RAILROAD.—A settlement was lately completed in Philadelphia between the Company and the Receivers of Jay Cooke & Co., by which the advances made by Jay Cooke & Co. to the Railroad Co. are discharged by the N. P. R. R. Co.'s First Mortgage Bonds and other securities, thus leaving the R. R. Co. with only a nominal floating debt to be provided for.

## *POLLUTION OF WATER.*

This subject is so important that we here reprint a *resume* of the results recently obtained by a French chemist, M. Musculus, communicated to the Academy of Sciences, in Paris, which appeared lately in the columns of our excellent contemporary, *Engineering*. The most able chemists differ both in their methods of analyzing impure water and in the results they obtain therefrom, and if this new method of analyzing shall prove so uniform in its results as to lead to its general adoption, we shall hail it with great satisfaction.

There are chiefly two tests by which the sanitary character of water, either of the ordinary supply, of wells, or of the effluent of a sewage farm, or the chemical treatment of sewage, may be estimated, viz: that of the physiological effects, and that by chemical analysis. The physiological method is that which is evidenced by the production of a certain class of diseases of the typhoid form from the use of impure water, of which instances are too familiar to require description. They exist in almost every large town; and, in fact, show the necessity of instant action for their prevention. But the physiological test is only of use as an indication of evil. It is. therefore, essentially followed by the chemical examination which, as we have just stated, is at once difficult and uncertain.

Careful observation, however, has shown that all the diseases of the kind to which we have referred, are invariably associated with the presencc of decomposing bodies containing nitrogen, either in the water supply or sewage. The source of this nitrogen is, for all practical purposes, as invariably derived from the refuse of animal existence. This nitrogenous refuse is composed of nitrogen, hydrogen, carbon, and oxygen. The ultimate products of the decomposition of such refuse are ammonia, carbonic acid, nitrates, and nitrites. Now these latter are all harmless *per se*. It is at the intermediate stage—that is the conversion of the refuse into these products—that danger arises to the animal system. But the presence of sulphur adds another element of danger, for by its respective combinations with hydrogen (sulphuretted hydrogen) and with nitrogen and hydrogen (suphide of ammonium), the two most dangerous gases which we have here named in brackets, as products, are afforded. But for our present purpose we entirely omit the consideration of the sulphur compounds.

It is evident, therefore, that if the chemist detect ammonia, nitrates and nitrites in any water, he *may* conclude that animal nitrogenons matter has been the cause of their production. As a rule this conclusion is invariably arrived at, as will be seen in the weekly or other reports of water-examiners, medical officers of health of our large towns. But as will be presently seen, other causes of the presence of ammonia exist, utterly unconnected with the animal nitrogenous refuse. It is this point to which we wish to draw special attention in the present article.

In England and France numerous instances have occurred in which gas works have been blamed for rendering water impure. In France actions have been brought and damages obtained against the companies who have been charged with injuring wells, &c., by the infiltration of water from their works. M. Boussingault has recently presented a paper to the Academy of Sciences, in which the experiments and results obtained by M. Musculus are fully detailed. Aware of the difficulty of the subject that chemist endeavoured to find a test by which the injury to well or other water could be distinguished as caused by sewage or gas waste, and his plan may be briefty explained as follows:

In examining water thus tendered impure he supposes that the presence of ammonia has hitherto been the crucial test of the cause of the pollution, But sewage water invariably, if freshly produced, contains *urea*, while gas refuse liquid contains none. If, therefore, urea bc found in the liquid it would certainly point out to sewage as the source of contamination. But urea on decomposing, produces ammonia, which is also contained in gas-refuse, as above stated. He, therefore, sought for a means of detecting urea, and has succeeded in producing a kind of a test-paper which seems well adapted for the purpose.

It appears from his researches that while urine is undergoing alkaline putrefaction small globules of a fermenting body are precipitated to the bottom of the vessel, and it is to these that the conversion of the urea into carbonate of ammonia is due. At first the liquid filters rapidly, but gradually passes much slower. This he ascribes to the globules of ferment obstructing the pores of the filter, and remaining therein. The filter is then washed with distilled water to remove all trace of alkali, and carefully dried at a temperature of 35 deg. to 40 deg. C. It should be coloured with a little tincture of tumeric, again dried, and then enclosed in a dry vessel to keep it from the action of moisturc. The paper thus contains in its pores the globules of ferment, which are inactive so long as they are kept dry.

To use the paper as a test for urea, a piece is immersed in the suspected liquid. Small brown spots will appear it urea be present, because by the action of the ferment it is converted into ammonia, which thus shows the usual alkaline reaction on the turmeric, and as the quantity of the ammonia increases the paper will gradually become browned wherever a globule of ferment exists. It is necessary to remove all alkaline carbonates previously in the liquid by dilute sulphuric acid, or deceptive results, arising from their action, would be afforded. Hc has attempted to make this method a means of discovering the total amount of urea present in a liquid. For this purpose a piece of paper is placed in it, a little tincture of litmus, and as much dilute sulphuric acid as will give the liquid the tint of the peel of an onion. The whole is to be heated for five or six hours to a temperature of 25 deg. to 30 deg. C. By the fermentation produced the urea will be converted into carbonate of ammonia, and hence by the usual method the amount of urea calculated. According to M. Musculus, the presence of uric acid, of albumenoid substances, and neutral salts, does not affect the accuracy of the results obtained.

Such is an outline of the plan proposed by that chemist. It is evident, on consideration, that it affords, so far as can be at present known, a very ready test for the cause of impurities in wells, brooks, &c., in respect to the refuse of gas works and sewage contamination. Its great value consists in distinguishing the source of nitrogen in the form of ammonia. We learn from the researches of Lehmann and others that an adult fed on average animal and vegetable food will void about 500 grains of urea daily; one on purely vegetable food about 348 grains; and one on purely animal food about 821 grains, falling to but 240 grains in a person using food from which nitrogen was carefully excluded. The average of urea in urine is about 14.25 parts in 1000 of the liquid.

Some very interesting points suggest themselves in this new method. Its value in distinguishing the difference between the impurities arising from gas refuse or sewage will be of great importance in jurisprudence. But as bearing on the results of various processes of treating sewage by irrigation, precipitation, or other means, it seems to open out a large field of inquiry that may be of essential service in controlling other methods of chemical analysis. Perhaps M. Musculus may have put us in a new direction that may afford more satisfactory results than have been as yet attained.

## *THE U. S. PUBLIC LAND SYSTEM.*

To subdivide the parallelogram lying *North* of the base line, and *West* of the principal meridian into townships, the government surveyor commences at the south-west corner of T. 1 N., R. 1 W., already established by a former surveyor, and proceeds due north 480 chains, establishing quarter section and section corners, until he sets the corners for township 1 and 2 north, ranges 1 and 2 west. Thence he runs east on a *random* line, setting temporary quarter section and section posts, to the north-east corner of the township, where the post has always been established. Thence, after making the necessary corrections for direction, he chains back on a *true line*, setting permanent corners every half mile, and throwing any excess or deficiency that may occur into the west half mile of the township. This completes the survey of T. 1 N., R. 1 W., and the surveyor then proceeds in a similar manner to survey T. 2 N., R. 1 W., and so on throughout the parallelogram, the small figures on the diagram A showing his perambulations until the whole is completed, taking notice however of the method adopted in the west tier of townships.

Parallelograms lying north of the base line, and *east* of the principal meridian, are similarly surveyed, except that random lines are run *West* and true lines run *East;* the excess or deficiency being thrown as usual on the west half mile, and the surveyor doing this by first measuring off on his *true* line from the west boundary the excess or deficiency, and then making the remaining measurements every forty and eighty chains.

The survey of parallelograms *south* of the base line, and west or east of the meridian, commences on the first standard parallel south at the south-west corner of T. 5 S., R. 1 W. or S. E. cor. of T. 5. S., R. 1 E. respectively, and is carried out exactly as those lying north of the base line.

To subdivide the townships into thirty-six sections of 640 acres each, as near as may be, the surveyor commences at the south-east corner of the township, and runs north one mile for the purpose of comparing his chain with that of the former surveyor, and to adjust his compass to the correct variation. These preliminaries attended to, he commences at the south-east corner of section 35, and runs due north, setting a quarter section corner at 40 chains, and a section corner at 80 chains; thence east on a random line to the east boundary line; if he intersects it at the corner, it is only necessary to set the temporary quarter post at the midway point between the section corners; if he intersects the east boundary to the north or south of the corner, the necessary correction must be made. The balance of the township is surveyed into sections in a similar way and after the method pursued in "townshiping," throwing the excess or deficiency on the north and west half mile. The numbers of the sections run from one—in the N. E. corner of the township—west to six; thence east to twelve; west to eighteen; and so on to thirty-six in the S. E. corner.

Corners are marked by setting posts or stones in mounds, with pits, varying in number, size and position according as they are used to make quarter section, section or township corners. In timber, trees found to be corners are marked, and where it can be done, "witness trees" are blazed and marked, and their size and bearings, and distances from the corner noted for future identification. The instruments most generally used for running lines are Burt's solar compass, and the open-sight vernier compass; measurements are made with a two rod chain.

[*To be continued.*]

## *ASTRONOMY.*

Measurement of Time—Time is the impression left on the memory by a series of events, of which we are certain that they were successive, and motion constitutes one of its most suitable measures. Thus, a pendulum returning again and again to the same position, and performing the same succession of motions, in obedience to the same forces, produces the idea of equal intervals of time, of which it becomes naturally a measure. Thus, the revolution of the stars becomes a natural measure of time, and one that has been used from the earliest ages; it has the advantage of being always the same, and is called a *sidereal day*.

In civil life, the day is the interval of time from sunrise to sunset, and night is the period during which the sun is below the horizon. The astronomical day contains the civil day and night, and is the interval from mid-day to mid-day, or from mid-night to mid-night.

The *astronomical day*, measured by the Sun's meridian passage, exceeds the *sidereal day*, measured by the meridian passage of any fixed stars, by nearly four minutes; but it is of different lengths on different days of the year, in consequence of the variable motion of the Sun, and in consequence of the obliquity of the ecliptic. If the length of the *solar day* be taken for all days in the year, and the mean of all calculated, the result is what astronomers call the *mean solar day;* this day is divided into 24 hours, each of which is divided into 60 minutes, and each minute into 60 seconds; the seconds so found are the units of time employed by all civilized nations.

If the Sun and a star pass the meridian together on any day, on the following day the Sun will be later than the star, in consequence of his own proper motion towards the east on the ecliptic. If the *mean solar day* be called unity, the *sidereal day* will be represented by 0·99726957.

The length of the year, or revolution of the Sun, may be determined either by the Sun's apparent motion among the stars, or by the interval between his returns to the same tropic, or same equinox. The first kind of year is called the *sidereal year*, and the other is called the *Tropical year*.

The *Tropical* year is, at present, 365·242264 days, or 365d. 5h. 48m. 51·6s.; while the sidereal year is longer by 0·014119 of a day, or 20m. 20s. It follows from this that the equinoxes have a retrograde motion on the ecliptic, opposite to that of the Sun, by virtue of which they describe on that circle, an arc each year, which occupies the Sun 20m 20s to traverse. The difference between the tropical and sidereal years causes the phenomenon called the *precession of the equinoxes*, which complete their revolution in the plane of the ecliptic in

$$\frac{365242264}{14119} = 25869 \text{ years.}$$

From the earliest times of Astronomy, the positions of the stars and other celestial bodies have been referred to the intersection of the Equator and Ecliptic, performing its complete revolution in the space of 25,869 years.

Since the formation of the earliest catalogue of stars on record, the place of the Equinox has retrograded by 30° of the whole 360° that constitute the Ecliptic.

[*To be continued.*]

## *GRAVEL STREET PAVING.*

There is probably no subject to which the attention of Engineers has so long been directed with regard to which conclusions are to-day so unsatisfactory as about Street Pavements.

A good pavement for the streets of American cities should be strong, dry, elastic, impervious to water and frost, smooth to the wheel and hoof without being slippery, not liable to wear or change to dust and mud, indestructible by the action of air, fire and water, and always reparable at small cost, without involving reconstruction.

Two other desirable points are, material at low cost, and admitting of construction without high priced or skilled labor.

Stone, wood, and the artificial mixtures—composite or concrete—seem to fail in some important particular.

One of the best is the old Telford Pavement upon a good foundation; but no stone has been found for it which at the same time has suitable properties for forming a water tight covering, and which is hard enough to resist the wear of heavy and continued use without pulverizing.

The streets of Paducah, Kentucky, are paved with a kind of gravel which appears to satisfy the requirements for a good street pavement better than any other in use.

This gravel is of angular flint and quartz pebbles. It occurs in immense beds in connection with sand colored red by iron oxide. Running through these deposits are thin strata, or sheets of almost pure iron, rarely more than an inch thick, and which appear to have been molten. There are also all through the beds veins and pockets of clay of various colors, which are nearly pure, and masses of sand.

The sand and the iron form the cement or setting in which each of the flint pebbles becomes imbedded by use. This action or cementing begins at once when the covering is applied to the street, and forms a smooth elastic surface equal to that of any other street formed by any other mode of any other material.

Time and continued use improves the character of this covering. The flint prevents any destructive wear, so that those which have been in use for twenty years do not exhibit much more evidence of wear than those recently constructed.

The material is very compressible. Where a depth of sixteen inches is used in the center of the street, it is found in twelve months to be compressed to less than one foot, and its compressibility is of course, proportioned to the amount of sand and iron in it.

It is compact like hard pan in its natural bed, when of good quality, but becomes much more so under wear and pressure. If care is exercised to exclude all clay from the material used, frost does not affect it injuriously. During the muddiest portions of the year, at a depth of three or four inches below the surface, the material is apparently as dry as in the summer.

The deposit is glacial drift, not river washed, and underlies a diluvial clay, or clay soil, at various depths.

It extends some sixty miles along the Tennessee and Ohio Rivers, the range pointing toward New Madrid, Missouri, the earthquake centre of this region. Branches or spurs put out from the main deposit, some of them crossing the Tennessee, the Cumberland, and the Ohio Rivers; but these seem to loose some of the most valuable properties for street purposes—are without iron or sand, or are too intimately mixed with clay

Paducah has more than twenty miles of streets paved with this gravel. No especial pains has ever been taken to so construct them as to have the best results. And for many years after it began to be used, its peculiar merits were not generally recognized. Yet these streets are unequalled by those of any other city in the country, and it is believed they are practically indestructible. If from any cause, as bad foundations, breaking up for gas or water mains, or excessive wear at one point, the original surface is destroyed, it can readily be restored by the application of fresh gravel, which at once amalgamates with the old mass. This makes the cost of repairs comparatively small. And kept in repair in this manner, no renewal or reconstruction will ever be required.

All this appears to the writer to indicate a good direction in which to look for a solution of what has been termed "the great American pavement problem."

Rock, wood, iron, asphalt, and all the compositions heretofore tried may be said to have failed—at least none of them met the requirements for a pavement satisfactory in all respects.

It is not then unlikely that a pavement composed of minerals harder and tougher than rock, and compacted by dry mineral cement, may supply this great want. *G.*

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LAKE SUPERIOR IRON DISTRICT.—The first forge erected in the Lake Superior District was erected in February, 1848. The first bloom was made by Mr. Olds, and was hammered into bar iron by Mr. Barnag. The first blooms made were sold to Capt. E. B. Ward, and from them was made the walking beam of the steamboat Ocean, long and honorably known as one of the North Shore line of steamers.

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COAL TRAFFIC.—Transportation of coal over the central division of the Central Railroad of New Jersey amounted in 1873, to 2,482,332 tons. In 1863 the transportation was 1,049,881 tons, or less one half; this year the Company have facilities to accommodate 5,000,000 tons of coal traffic if necessary.

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CHILI AND THE ARGENTINE REPUBLIC.—It is said that a contract has been signed for the construction of a railway between Chili and the Argentine Republic, via the Uspallata Pass. Length of the line to be 84 miles, steepest gradient to be 211 feet to the mile. A tunnel 2 miles long is proposed at Cambro which is 1,200 feet above the level of the sea.

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## *CANADIAN SURVEYORS.*

In the neighboring Dominion, the profession of surveying ranks much higher than in our republican country. There, no person can act as a surveyor of lands who has not been duly authorized to practise as such in accordance with the provisions of the Land Surveyors Act.

Examiners are appointed for each province before whom all intending surveyors must pass two examinations; the first, a "preliminary" to enable the applicant to be admitted as an apprentice, and the second —a "final," after the necessary three years apprenticeship has been completed and the applicant is admitted to practise as a Provincial Land Surveyor.

To be a P. L. S., the candidate must be twenty one years of age, must have "gone through" the first six books of Euclid, Plane Trigonometry, Mensuration of Superficies, Platting and Map Drawing, and be well versed therein: must also be sufficiently conversant with Spherical Trigonometry and Astronomy, to enable him to ascertain latitudes and meridian lines; must be conversant with the rudiments of Geology, but above all, must have served regularly and faithfully, "without money and without price," for and during the space of three successive years, as an apprentice to a Land Surveyor in one or the other Province and be able to show a certificate of such servitude.

The law provided also that where an apprentice, having passed through the regular sessions of any provincial University and received a diploma as a Civil Engineer and Land Surveyor, and afterwards completed as an apprentice the full term of three years, he should have the right to present himself for final examination and if found qualified, admitted to practice.

But "premiums" and long sessions, being more acceptable than intelligence to the sapient examiners at Toronto and Quebec, it was soon made unpleasant for candidates under the University Act, and we believe that very few young men availed themselves of its benefits. (We wish to be corrected by any of our professional brethren in the Dominion, if this last statement is not true, and would like to have the provisions of the present University Act if there is one.)

Every candidate for final examination must be the owner of a Theodolite or a Transit, and if the latter, it must have a vertical arc attached for measuring altitudes.

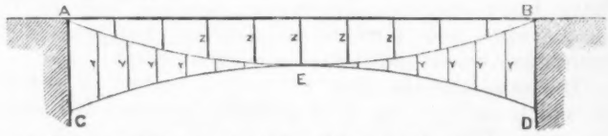
Examinations are held every three months and vary in length from two days to two weeks according to circumstances. The successful candidates having taken theoaths of office and allegiance, deposited the necessary bonds for the faithful performance of their duties and paid the required fees, are dubbed P. L. S. and presented with a diploma, a standard measure, and a copy of the surveyor's act after which they are ready to offer their services wherever they may choose to locate.

## *RIGID SUSPENSION BRIDGES.*

In a paper recently read before the Civil Engineers' Club of the North-west, Mr. Chas. Quetil, C. E., gave a description of the system of building rigid suspension bridges, proposed by M. Leblanc, Chief Engineer to the corps of "*Ponts et Chaussees*," in which he claims that the problem of constructing a bridge without interfering with navigation of the river is solved. This system may be described in Mr. Quetil's own words, as follows:

"He, M. Leblanc, thinks to be able to establish suspension wire or chain bridges, subject to very little oscillations, and of spans as long as those of the longest suspension bridges already built. He starts from this principle, that if the flooring of suspension bridges, instead of being attached to flexible cables, whose form gets altered as soon as the flooring raises up or lowers down by the action of the wind or some other cause, was on the contrary, invariably attached, by means of rigid rods, to a system of bars rigid by itself and uniting the two abutments, no raising up or lowering down of the flooring would be possible."

It may be further explained by reference to the following diagram:




A E B, C E D, are to flexible suspension chains or cables, the former being hung in the ordinary manner, the latter inverted and attached to the former by the tension rods *y*, *y*, *y*, &c. At the ends these cables are firmly attached to the abutment piers A C, B D, which are constructed of masonry, as usual, and of sufficient strength and weight to resist the strains caused by the tensions in the cables A E C, C E D. The cables when loose and uniformly loaded, assume very nearly the form of a parabola. Nuts are screwed on the ends of the tension-rods *y*, *y*, *y*, &c., whereby they and the cables are tightened up and an initial strain put upon them equal to that which would be produced by the maximum calculated load which will come upon the bridge. In the triangular frame A E C (or B E D), the strain on the members A E, C E, *y*, *y*, *y*, &c., is tension, and that on the member A C, compression. This system A C E B D is the rigid system described above.

We have not space to enter into the whole subject critically on this occasion, but take for the present the third general case described by the author and illustrated in the diagram, in which the platform A B of

the bridge is supported above, and upon the rigid system A C E B D, by the struts $z$, $z$, $z$, &c. Under the head of "*Effect produced by the passage of trains*," Mr Quetil takes for illustration a bridge of 300 metres, or 328.09 feet span, in which the two cables have respectively a depression and rise of 1-20th or 16.4 feet, and an initial tension put upon them and the rods $y$, $y$, $y$, &c., such as "would be produced by the passage of a train weighing 840 lbs. per lineal foot and covering the whole length of the bridge." From these data and that of the weight of the structure itself (unloaded), and the strain produced by the initial tension, which, conjointly, he estimates at 2327 lbs. per lineal foot of bridge, the author calculates the maximum tension of the upper chains or cables at 21360 lbs., their section being 91.2 square inches, and the length of the parabolic arc = 330 feet 2¼ inches.

"Under the weight of the running load (840 lbs. per lineal foot), the tension will become 28366.7 lbs. per square inch, and the lengthening of the parabolic arc will be 15-16 of one inch. This increase of length corresponds to an increase of depression of about 3⅛ inches. Consequently at the passage of such a train the bridge, in its middle part, would have a tendency to lower down 3⅛ inches. But it is easy to see that the total lowering of the bridge, in its middle part, will not amount to 3⅛ inches, and will not be more than 1 9-16 inch. In fact, the primitive tension exerted by the cables one upon the other and equal to this produced by a load of 840 lbs. per lineal foot increases reciprocally their depression and rise by 3⅛ inches. As soon as that tension would cease to exist the depression would be smaller by 3⅛ inches and the top cable would rise 3⅛ in.

Now, if on account of the additional live load, the flooring lowers down 3⅛ inches, it is evident that the lower cable ceases to exert any tension, and the top cable will rise immediately; but these effects are not produced successively or one after the other, but on the contrary, simultaneously or one at the same time as the other, the tension of the cable diminishing progressively and the force acting to raise the top cable increasing in the same proportion as the top cable has a tendency to lower down. Those are two equal forces acting in contrary direction, and which will equilibrate each other at half the distance between the limits of motion, so that the lowering of the flooring, at half that distance, or in the center of the bridge will be only 1 9-16 inch."

The whole subject is one of great importance, and we thank Mr. Quetil for having brought into prominent notice by a carefully and exhaustively written paper, a method of stiffening suspension bridges but very little known in this country heretofore. It is our intention to refer again to this system of long-span bridges when writing upon and comparing the merits of other systems either proposed or in use.

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